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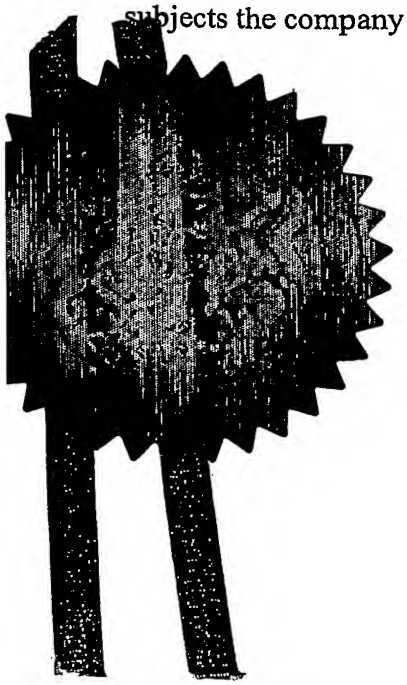

Signed J Evans.

Dated 3 August 2004

THE PATENT OFFICE
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- 1 JUL 2003
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01JUL03 E819015-1 D10158
P01/7700 0.00-0315273.3

Patents Form 1/77

Patents Act 1977
(Rule 16)

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

P172-GB

2. Patent application number
(The Patent Office will fill in this part)

0315273.3

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

1... Limited
St John's Innovation Centre
Cowley Road
Cambridge CB4 0WS

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

England

8113870001

4. Title of the invention

LENS SUSPENSION AND ACTUATION APPARATUS

5. Name of your agent *(if you have one)*

Akram K. Mirza
1... Limited
St John's Innovation Centre
Cowley Road
Cambridge CB4 0WS

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Patents ADP number *(if you know it)*

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	7
Claim(s)	2 CE
Abstract	1
Drawing(s)	3 only

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature  Date 01-JUL-2003

12. Name and daytime telephone number of person to contact in the United Kingdom Akram K. Mirza 01223-422290

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

LENS SUSPENSION AND ACTUATION APPARATUS

FIELD OF THE INVENTION

This invention relates to apparatus for suspending and actuating a lens assembly or lens barrel. More specifically it is directed to such an apparatus for micro-cameras in portable data processing or communicating devices. And even more specifically, it pertains to such apparatus for use in a camera with an electric-active actuator.

BACKGROUND OF THE INVENTION

In recent years, with the explosive spread of portable information terminals called PDAs and portable telephones, an increasing number of models have been coming to incorporate a compact digital camera or digital video unit employing a CCD (charge-coupled device) or CMOS (complementary metal-oxide semiconductor) sensor as an image sensor. When such a digital camera or the like is miniaturized using an image sensor with a relatively small effective image-sensing surface area, its optical system also needs to be miniaturized accordingly.

To achieve focussing or zooming, additional drive motors have to be included in the already confined volume of such miniature cameras. Whilst most of the existing cameras rely on variations of the well-known electric-coil motor, a number of other actuators have been proposed as small drive units for the lens system. These novel drive units often include transducers based on piezoelectric, piezoresistive, electrostrictive or magnetostrictive material. These transducers or actuators are commonly referred to as electro-active.

Small electro-active actuators with comparably large translation displacements have been recently build using a

helical structure of coiled piezoelectric tape. Such twice-coiled or "super-helical" devices are found to easily exhibit displacement in the order of millimetres on an active length of the order of centimetres. These structures and variations thereof are described, for example, in the published international patent application WO-0147041 or by D. H. Pearce et al in : Sensors and Actuators A 100 (2002), 281 -286. They are manufactured from multilayer ceramic base material such as lead zirconate titanate (PZT) and sintered at high temperatures into their final shape. The use of such actuators as drive motor for lens systems is described for example in the co-owned published international patent application WO-02/103451.

As drive units adapt to the reduced volume of the compact camera designs, lens suspensions systems, which constrain the motion of the lens holder, have to co-evolve. Lens suspension systems ideally have a low stiffness, resistive force or friction in direction of the desired motion and high stiffness in all other directions.

Therefore it is seen as an object of the invention to provide a lens suspension system suitable for miniaturized cameras, particularly for cameras driven by an electro-active transducer.

SUMMARY OF THE INVENTION

According to an important aspect of the invention, there is provided a camera including a support structure; a lens holder with at least one lens; a suspension for mounting said lens holder on support structure; and an actuator for moving said lens holder, wherein the suspension includes an upper and a lower link element each pivotally connected to the support

structure at one end and pivotally connected to the lens holder at another end.

The suspension system is preferably a variant of a four-bar linkage. The suspension system can be formed from one continuous piece of material, preferably a plastics material, selected for example from a group including polypropylene, polyethylene and polyamide (nylon).

In another preferred embodiment of the invention, the thickness of the link element tapers towards the pivotally connected ends such that the link element is thicker in the middle than in the immediate vicinity of the pivots or hinges.

In another preferred embodiment the pivotally connected ends of the suspension extend along the circumference of the lens holder, preferably such that the length of a line connecting the end points of one pivot or hinge exceeds a tenth more preferably a third or even half of the diameter of the lens holder. The thus extended pivot can sustain a higher torsional force without significant deformation.

In a preferred embodiment the actuator extends around the lensholder leaving a single one gap with the suspension located in said gap. In this embodiment, the suspension supports the lens holder at just one side or in the terms of a cylindrical lens holder within just one sector. The sector, measured by connecting the end points of the longest pivot that is located at the lens holder with the center of the lens holder, is preferably less than 90 degrees. As a result, the lens holder is suspended at a quarter or less of its circumference - excluding the suspension effected by the actuator.

In some variants of the invention it may advantageous to limit the amount of rotational motion around the pivoting ends to less that 20 degrees. As a result the lens holder's motion is limited to the equivalent maximum displacement thus improving the protection of the actuator.

These and other aspects of inventions will be apparent from the following detailed description of non-limitative examples making reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1A is a perspective view on a camera housing;

FIG. 1B is a perspective view on the camera housing of FIG. 1A with a top lid removed; and

FIGs. 2A and 2B are perpendicular schematic cross-section of the camera housing of FIG. 1.

DETAILED DESCRIPTION

In FIG. 1A, there is shown a camera housing **100** with a miniature camera. The housing includes a top lid **101** with a central opening or aperture **102** for the passage of light from the exterior into the interior of the housing. The opening can be covered by an optical filter. The lower section of the housing includes a bottom lid **103** and a base plate **104**. The base plate carries the image sensor (not shown) which may be a CCD or CMOS device (not shown) together with other circuits to capture the image and transmit it to other parts of the camera.

At one side of the housing there is shown an anchor plate **105** which provides mounting points for a suspension system to be described below. Another plate **106** is used to mount the fixed end **111** of a piezoelectric actuator **110**.

To further protect the camera and the actuator, the housing 100 may be cast into a block of suitable plastic material.

FIG. 1B shows the housing **100** with the top lid **101** removed thus exposing the lens holder or barrel **120** with a first upper lens **121** visible. The lens barrel has a nominal cylindrical shape that is flattened along one side **122** to provide a mounting surface for the suspension **130**.

The actuator **110** is a helically wound piezoelectric bender with the helix wound again into a three-quarter turn. The lens barrel **120** is placed in the center of the lens barrel. The moving end **112** of the actuator is attached to the lens barrel at a point or area at mid-height of the lens barrel, i.e., close to its equator. The fixed end **111** of the actuator **110** extends into a flat portion. This tab has electrical contact pads **113** on the bottom face, soldered onto corresponding contact points on the board **106**. Through these contacts external control signals or voltage levels are applied to the electrodes of the actuator **110**.

The cross-sectional view of FIG. 2A shows the four links of the suspension **130** arranged in a parallelogram with hinges at each corner. The suspension is a specific form of a four-bar linkage. The ground link **132** is rigidly connected to the housing **101**, **103**. The coupler link **134** is rigidly connected to the lens holder **103**. The "grounded links" **133**, **135** provide the elements that rotate about the pivots or hinges. The thickness of each link tapers towards the hinges such that at the hinge

the material is reduced to a thin bridge connecting two links, whilst the middle section of each link remains stiff. As a consequence the suspension and its links offer small resistance against motion of the barrel in the desired (vertical) direction but much greater resistance against motion in other directions. The links and, hence, the hinges have a width of about 4 mm and the nominal diameter of the lens holder **120** is 9.5 mm, thus effectively preventing a rotational or tilting movement of the barrel.

Each of the hinges or pivots extends linearly in the direction of its axis of rotation, thus enabling the hinge to resist torsional forces which otherwise could lead to a tilting of the suspended camera. The length of the pivot or hinge section in the above example is approximately a third to half of the diameter of the lens holder.

In the example, the suspension 100 is made from a single piece of polypropylene. Other suitable plastic materials include polyethylene or polyamide (nylon). Alternatively the bars of the suspension can be made from metals or metal alloys. The suspension can be cast or injection molded.

It will be appreciated that the lens holder **120** is suspended solely by means of the suspension **130** and the actuator **110**. The system is free of further potential sources of friction such as guide rails or posts to reduce the potential amount of force the actuator has to provide. It was found that even though the suspension connects to the lens holder exclusively within a sector of less than 90 degrees, and both the actuator and the suspension are linked to the lens holder within a sector of less than 120 degrees, the tilt of the lens holder can be kept within the limits required to generate pictures in VGA or SVGA quality.

Also visible in FIGs. 2A and 2B are polyurethane foam layers **108** glued to inner surfaces of the housing **100** around the actuator **110**. The layers protect the actuator from a sudden impact force, particularly if the force accelerates the actuator in a direction that is not constrained by the suspension **130**. In FIG.2, this direction is the vertical direction in the paper plane. The distance between the actuator **110** and the foam layers **108** increases towards the moving end of the actuator, so as not to interfere with the nominal displacement of the actuator during the normal operation of the camera.

CLAIMS

1. Camera comprising
a support structure;
a lens holder with at least one lens;
a suspension for mounting said lens holder on support structure; and
an actuator for moving said lens holder, wherein the suspension includes an upper and a lower link element each pivotally connected to the support structure at one end and pivotally connected to the lens holder at another end.

2. The camera of claim 1 wherein the link elements form a four-bar linkage.

3. The camera of claim 1 wherein the link elements form a parallelogram.

4. The camera of claim 1 wherein the link elements are formed from one continuous piece of material.

5. The camera of claim 1 wherein the link elements are made of plastics material.

6. The camera of claim 1 wherein the link element thickness tapers towards the pivotally connected ends.

7. The camera of claim 1 wherein a pivot extends along the circumference of the lens holder.

8. The camera of claim 1 wherein the length of a line connecting end points of a pivot exceeds a tenth of the diameter of the lens holder

9. The camera of claim 1 wherein actuator extends around the lens holder leaving a single gap and the suspension is located in said gap.

10. The camera of claim 1 wherein actuator extends continuously around the lens holder leaving one gap and the suspension is located in said gap.

11. The camera of claim 1 wherein the suspension connects the support structure and the lens holder within a cylindrical sector of less than 90 degrees around a central axis of said lens holder.

12. The camera of claim 11 wherein the lens holder is exclusively force-coupled to the housing through the suspension and the actuator.

13. The camera of claim 1 the amount of rotational motion around the pivoting ends is limited to less than 20 degrees.

ABSTRACT

A suspension system for a miniature camera wherein a number of pivotally connected link elements in form of a parallelogram connect the housing and the lens or lens holder.

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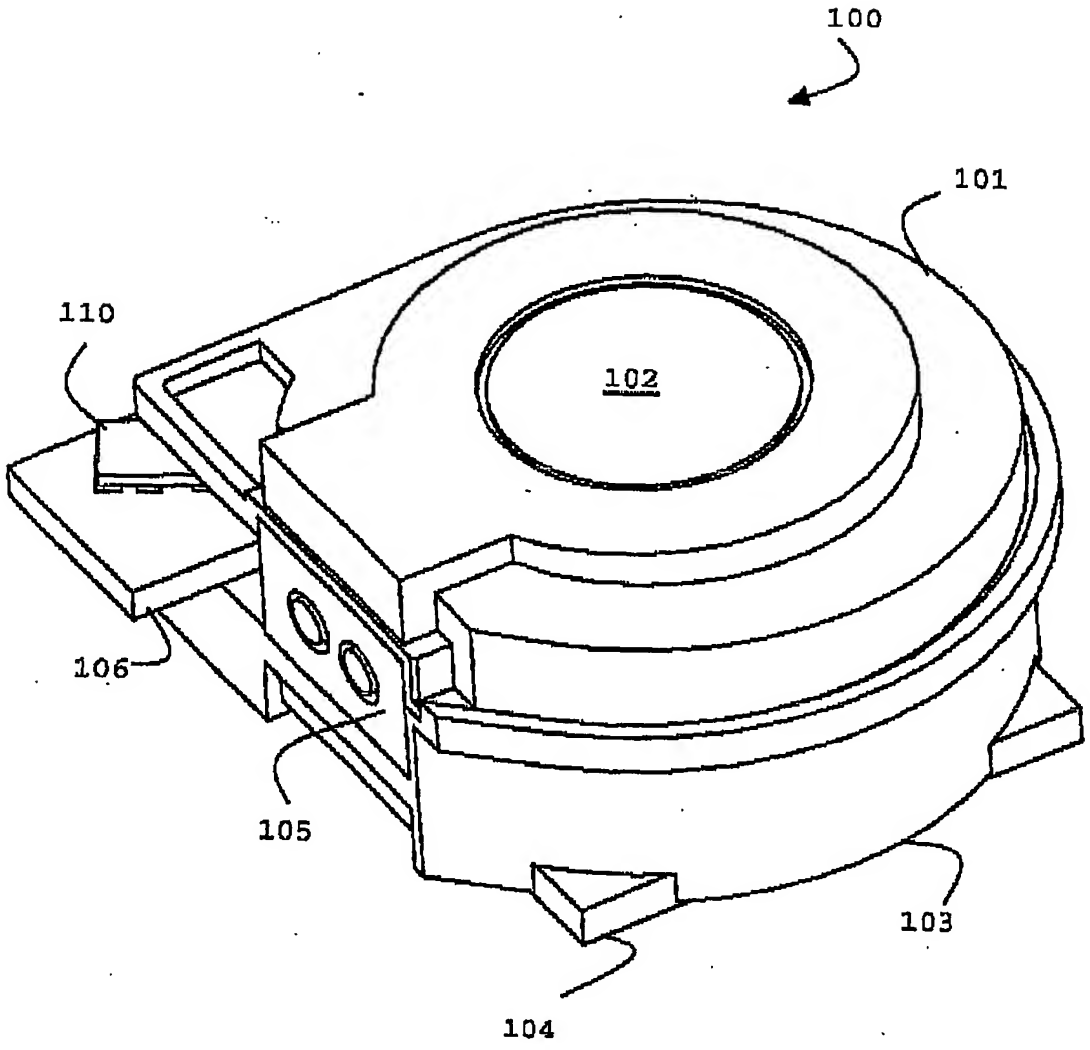

FIG. 1A

P172-GB

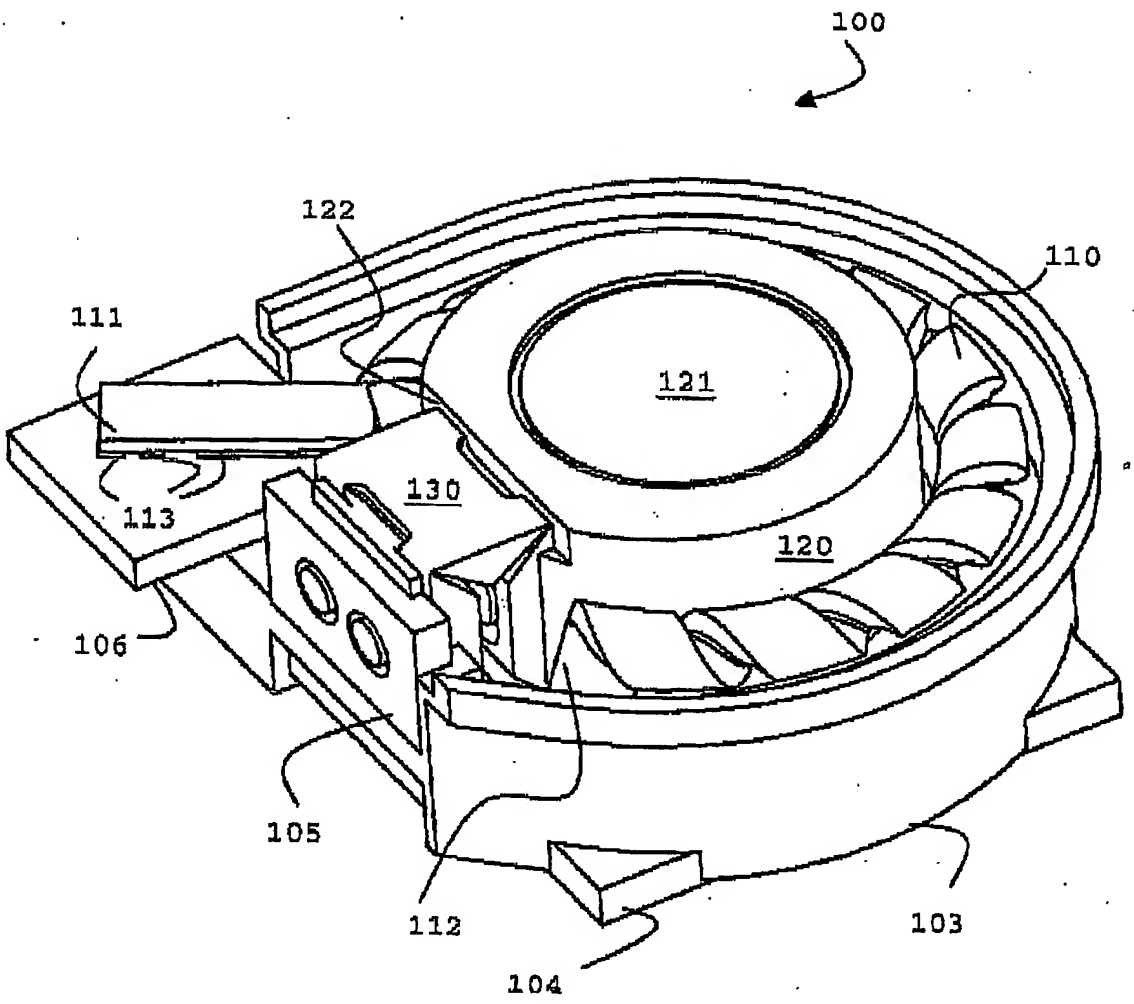

FIG. 1B

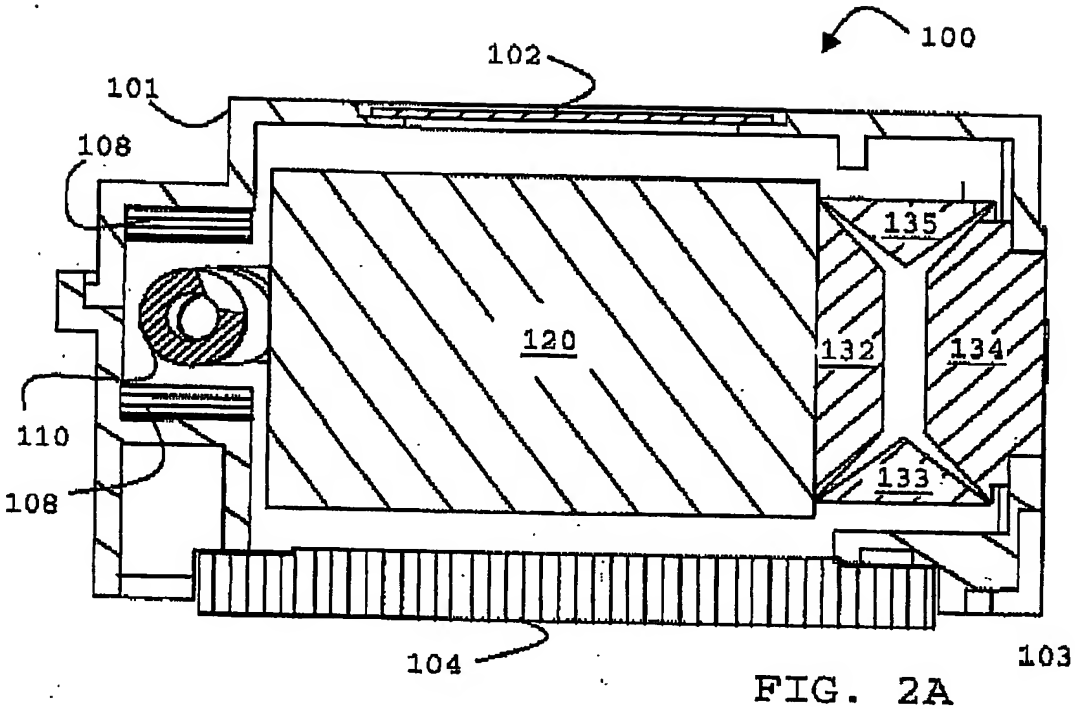
100
102
101
108
135
120
132
134
110
108
133
104
103

FIG. 2A

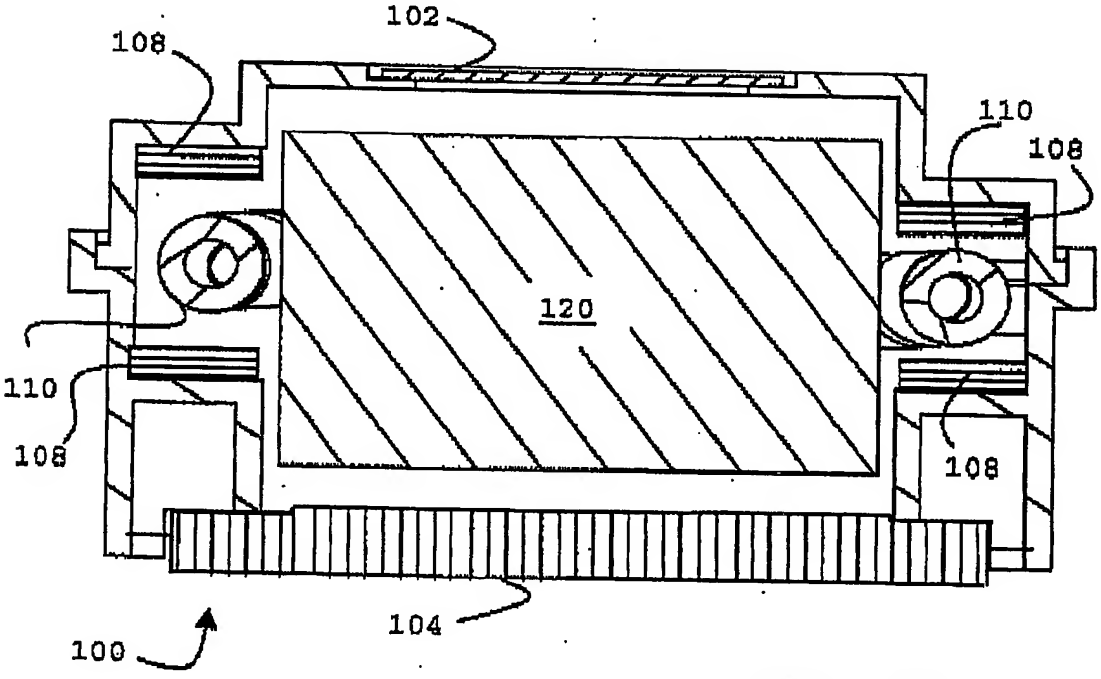
102
108
110
108
120
110
108
108
104
100

FIG. 2B